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Applicant: Michael B. Simpson, et al.

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Sir:

Transmitted herewith for filing under 37 C.F.R. § 1.53(c) is the provisional patent application of:

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[X] Applicant claims small entity status under 37 CFR 1.27.

Enclosed are:

☒ Specification (42 pages);

☒ Application Data Sheet (37 CFR 1.76) (4 pgs).

The filing fee is calculated below:

									Fee Total
Basic Fee							$160.00		$160.00
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			TOTAL FILING FEE:					=	$80.00

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☒ Further, Applicant, by and through its attorney of record, hereby expressly abandons the application as of the filing date of this application. This is an abandonment of the application only, and is not to be construed as an abandonment of the invention disclosed in the application. It is respectfully requested that the Office acknowledge the abandonment of the application as of the filing date of this application in a communication mailed to the undersigned.

Please direct all correspondence to the undersigned attorney or agent at the address indicated below.

Respectfully submitted,

Date: July 8, 2004

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9130-101

CHEMICAL MIXING APPARATUS, SYSTEM AND METHOD

Related Application

[0001] This provisional patent application incorporates by reference U.S. non-provisional patent application, entitled CHEMICAL MIXING APPARATUS, SYSTEM AND METHOD, filed July 9, 2004, attorney docket number 9130-100.

Field of the Invention

[0002] The present invention relates in general to an apparatus, system and method for mixing chemicals. It more particularly relates to such an apparatus, system and method for mixing ingredients in a precise manner in accordance with a given recipe.

Background Art

[0003] This section describes the background of the disclosed embodiment of the present invention. There is no intention, either express or implied, that the background art discussed in this section legally constitutes prior art.

[0004] There have been a variety of different types and kinds of apparatus, system and methods for mixing ingredients. For example, reference may be made to the following U.S. patents and patent application, each of which is incorporated herein by reference in its entirety:

Patent No.	Inventor	Issue Date
4,363,742	Stone, Milton	12/14/82
5,340,210	Patel, et al.	08/23/94
5,348,389	Lennart Jönsson, et al.	09/20/94
5,522,660	O'Dougherty, et al.	06/04/96
5,632,960	Ferri, J.R., et al.	05/27/97
5,874,049	Ferri, J. R. et al.	02/23/99

5,924,794	O'Dougherty, et al.	07/20/99
6,120,175	Tewell, Stanley	09/19/00
6,290,384	Pozniak, et al.	09/18/01

Patent Application No.	Inventor	Issue Date
2004/0100860	Wilmer, et al.	05/27/04

[0005] Currently, many manufacturing processes require the use of blended chemical compositions to treat parts during different steps of the process. Historically, these blended compositions have depended upon the input chemical control devices to achieve the desired mixture, then the mixture is tested in line for acceptable use. In some cases, an external analytical instrument or laboratory is used to confirm the blended mixture. In some other cases, an in-line test on the product is used.

[0006] While these methods may be successful for some applications to assure quality of process, they each may employ unwanted and undesirable delays. If the test fails, draining and refilling the chemistry subsequent to the test results may be required. This may result in unacceptable delays, additional costs and additional cycle time to the manufacturing process in certain applications.

Brief Description of the Drawings

[0007] The following is a brief description of the drawings:

[0008] FIGS. 1-23 illustrate various features of the disclosed embodiments of the invention.

Detailed Description of Certain Embodiments of the Invention

George V Woodley
14 March 2003

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Chemistry

The system is capable of handling the following Horiba monitors by use of compile-time configuration:

Horiba ID	Label[1]	Alt Label[2]	Chem1	Chem2	Chem3
CS-131	SC1	APM	NH_4OH	H_2O_2	H_2O
CS-210/220	SC1	APM	NH_4OH	H_2O_2	H_2O
CM-200/210	HF		HF	TEMP[3]	none
CS-342	SC2	HPM	HCL	H_2O_2	H_2O
CS-340	SPM		H_2SO_4	H_2O_2	H_2O
CS-327	BHF		NH_4OH	HF	H_2O

Table 1 Analyzers handled by TakLdm

[1] The label is the 3-letter combination identifying the measured chemistry.
2 The alternate label is chosen by the configuration.
[3] Temperature

System Block Diagram

The system consists of the following modules:

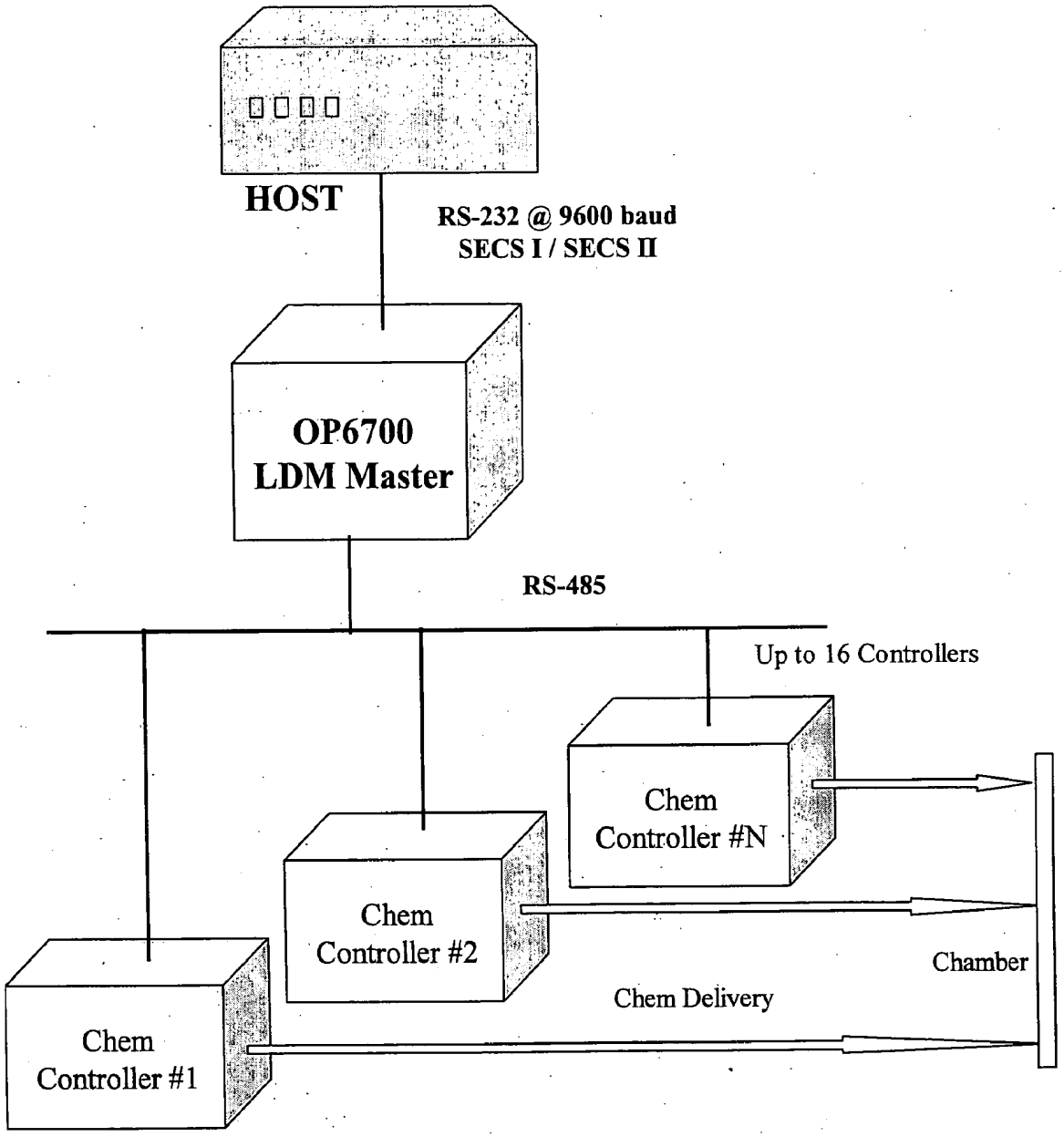


Figure 1 LDM System Diagram

LDM Master

The LDM Master is a ZWorld OP6700 (Intellicom) computer. It receives recipes and commands from a Host computer (not part of the LDM configuration). This computer communicates with the Host via an RS-232 serial link at 9600 baud using the SECS I / SECS II protocol. The message details are discussed in document TresSecs.doc Rev A (to be issued shortly).

The LDM Master communicates with up to 16 Chemistry Controller Slaves via an RS-485 network. Communication consists of the following information:

1. Commands from the Host relayed to the Chem. Controllers.
   - Recipes
   - Chem. Delivery Commands
   - Limits and Setpoints.
2. Commands to the Chem. Controllers originating with the LDM Master.
   - Pour-up commands based on time and tank utilization
3. Data from The Chem. Controllers relayed to the Host.
   - Measurements
   - Chemical quantities delivered by the Controller.
   - System Error messages
   - Limits and Setpoints (when changed by the operator, or restored after power-up).

Local Operator Interface

A limited Operator Interface is available with the OP6700. This is used as an auxiliary communications device, since the main communications are achieved from the Host.

- 2 x 6 domed tactile keypad
- Supertwist 4 x 20 LCD display with backlighting.

EG2100 (RabbitLink)

The ZWorld RabbitLink board is connected to the OP6700 during development, and enables Internet-based downloading and debug of LDM Master software.

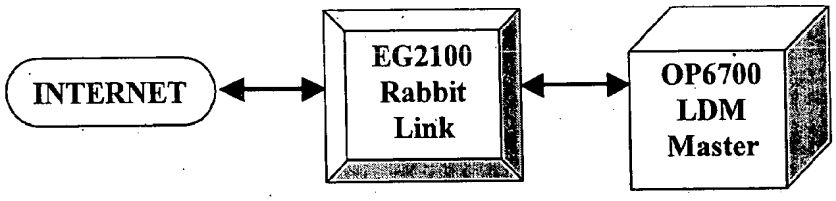


Figure 2 Use of the Internet to download and debug LDM Master programs

Chem. Controller

The Chemistry Controller is the ZWorld PK2600 (Gemini) and is an extension of the TAK2600 design (Reference: TAK2600.doc, Rev A).

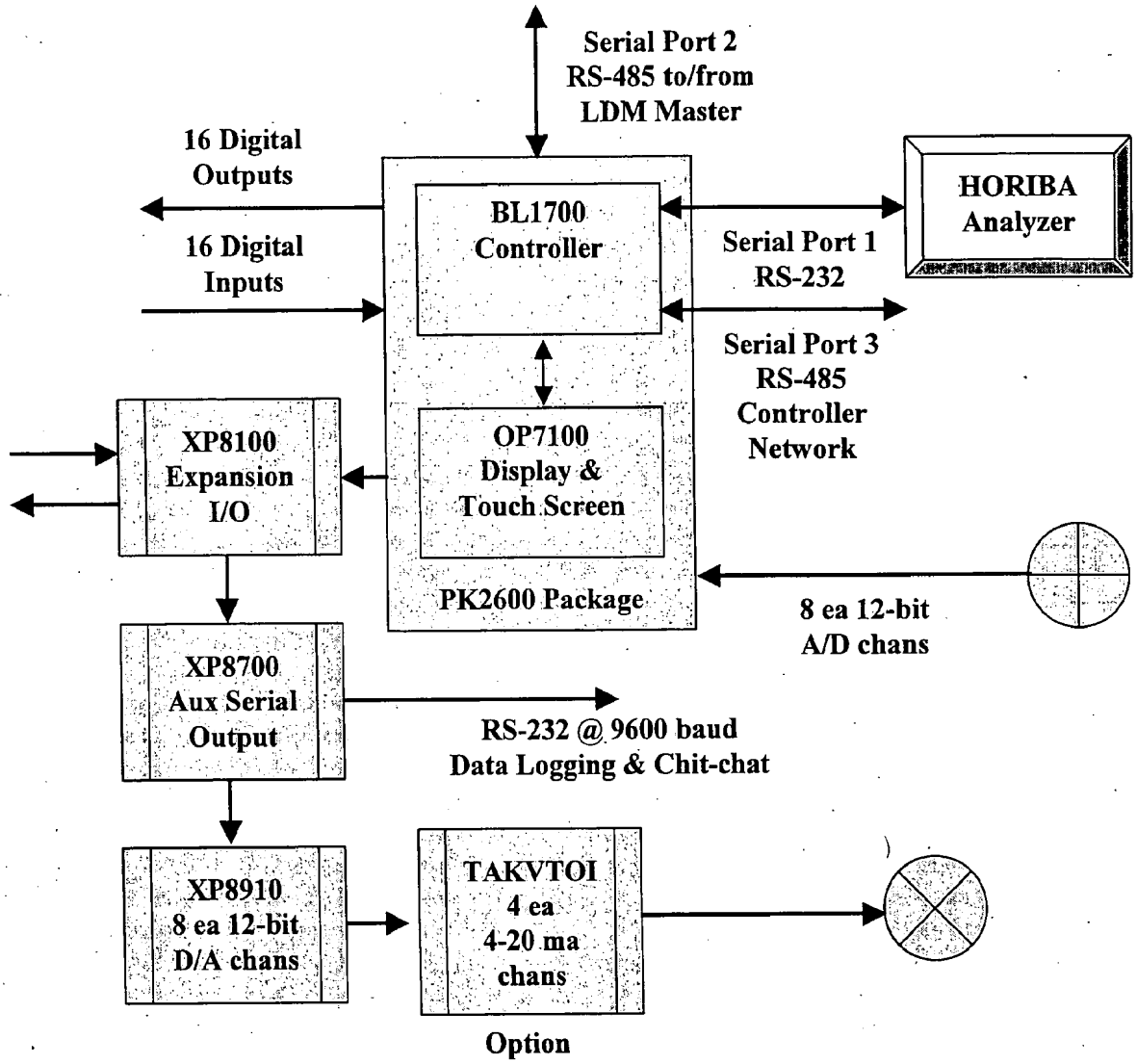


Figure 3 Chemistry Controller

The PK2600 package consists of two board-level computers sandwiched together, and an expansion board connected to the PLCBus port:

- The BL1700 controller provides the I/O functions.
- The OP7100 provides a ¼ VGA display screen and an 8 x 8 touch screen

Additional modules connected via the PLC bus at the rear of the PK2600 include:

- The XP8910 provides 4 each 12-bit Digital-to-Analog (D/A) channels.
- The XP8100 provides additional I/O: 16 Digital Inputs and 16 Digital Outputs

- The XP8700 provides an auxiliary serial output to be optionally used for local Data Logging and Chit-chat (program progress).

The following I/O is provided by the BL1700:

- An RS-485 serial port to interface with the LDM Master.
- An RS-232 serial port to interface with the Horiba Analyzer at 9600 baud
- An RS-485 serial port to be used for Temperature Controller network.
- An RS-232 serial port used internally to communicate with the OP7100.
- 16 high-current digital outputs drive solenoids and relays directly.
- 16 digital inputs are protected against damage in the range of +/- 48 V, and can operate continuously in the range of –20 V to +24 V.
- 8 conditioned 12-bit Analog-to-Digital (A/D) channels, up to 3500 samples/second. Configured for a 0-5 VDC (optionally 0-10 VDC) range.

The XP8910 is connected via the ZWorld PLC bus cable

- Provides 4 each 12-bit Digital-to-Analog (D/A) channels in the range of –10 V to +10 V DC. This is constrained by software to the range of 0 to +5 VDC (optionally 0 to +10 VDC).
- An optional TresArk TakVtoI module can convert this range to 4 channels of 4-20 ma.

Other devices which may be optionally connected via the ZWorld PLC bus cable:

- The XP8700 provides an auxiliary serial output.

Chem. Controller Connections (base configuration)

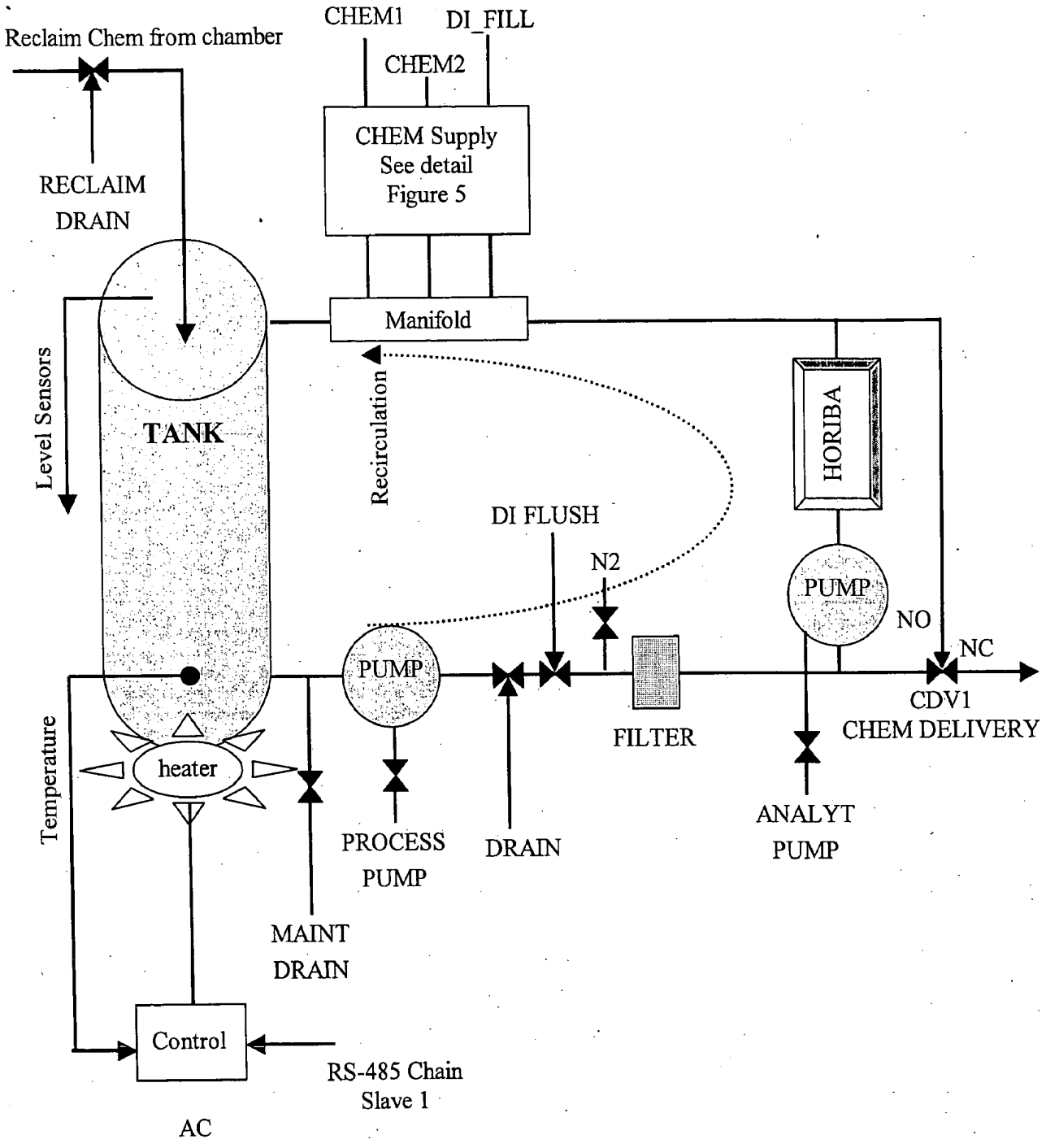


Figure 4 Chemistry Controller Connections (base configuration)

The base configuration of the Chemistry Controller provides the following capabilities:

- Pour-Up of a tank of desired chemistry and temperature (two chemicals and De-ionized Water).
- Replenishing the tank during operation when the level falls below a certain level.
- Spiking of the tank during operation with two chemicals when the concentration falls below a certain level (CLOOP action).
- Calculation of CHEM and DI flow times based on valve coefficients and Metering Pump characteristics.
- Delivery of the mixed contents of the tank to the processing chamber for a certain period of time ("straight pipe" configuration).
- Chemical from the chamber can be recycled to the tank (or dumped to the drain) under control of the chamber.

Level Sensors:

MAX_LEVEL	Absolute maximum. CLOOP is inhibited if this is TRUE.
HI_LEVEL	Stop filling here during Pour-up.
LO_LEVEL	Stop draining here during Pour-up.
REP_LEVEL	Perform Replenish action when this level is reached during normal operation.
HILEVPRE_DI_FILL	High-level sensor for DI_FILL pre-weigh.
LOLEVPRE_DI_FILL	Low-level sensor for DI_FILL pre-weigh.

Liquid Flows

CHEM1	Add Chemical 1 during CLOOP active.
	Add Chemical 1 during Pour-up.
CHEM2	Add Chemical 2 during CLOOP active.
	Add Chemical 2 during Pour-up.
DI_FILL	Add H_2O during the Fill Cycle.
DI_FLUSH	Add H_2O during the Flush cycle.
N2	Nitrogen is used during the Flush cycle.
DRAIN	Used to drain tank during the Flush cycle.
MAINT_DRAIN	Used by Maintenance to completely drain the tank.
RECLAIM_DRAIN1 or 2	Used to drain or recycle chemical from chamber 1 or 2
CDV1	Chemical Delivery, channel 1
CDV2	Chemical Delivery, channel 2 (Option D2)

Pumps

PROCESS_PUMP	Provides re-circulation flow
ANALYT_PUMP	Provides flow through Horiba analyzer

Metering Pumps

CHEM1_MP	Add CHEM1 (base configuration)
CHEM2_MP	Add CHEM2 (base configuration)

Temperature Control

TC1	Controls temperature in the DI_FILL Pre-weigh RS-485 Chain, Slave 1.
TC2	Controls temperature in the Main Tank RS-485 Chain, Slave 2.

Chem. Supply Detail (base configuration)

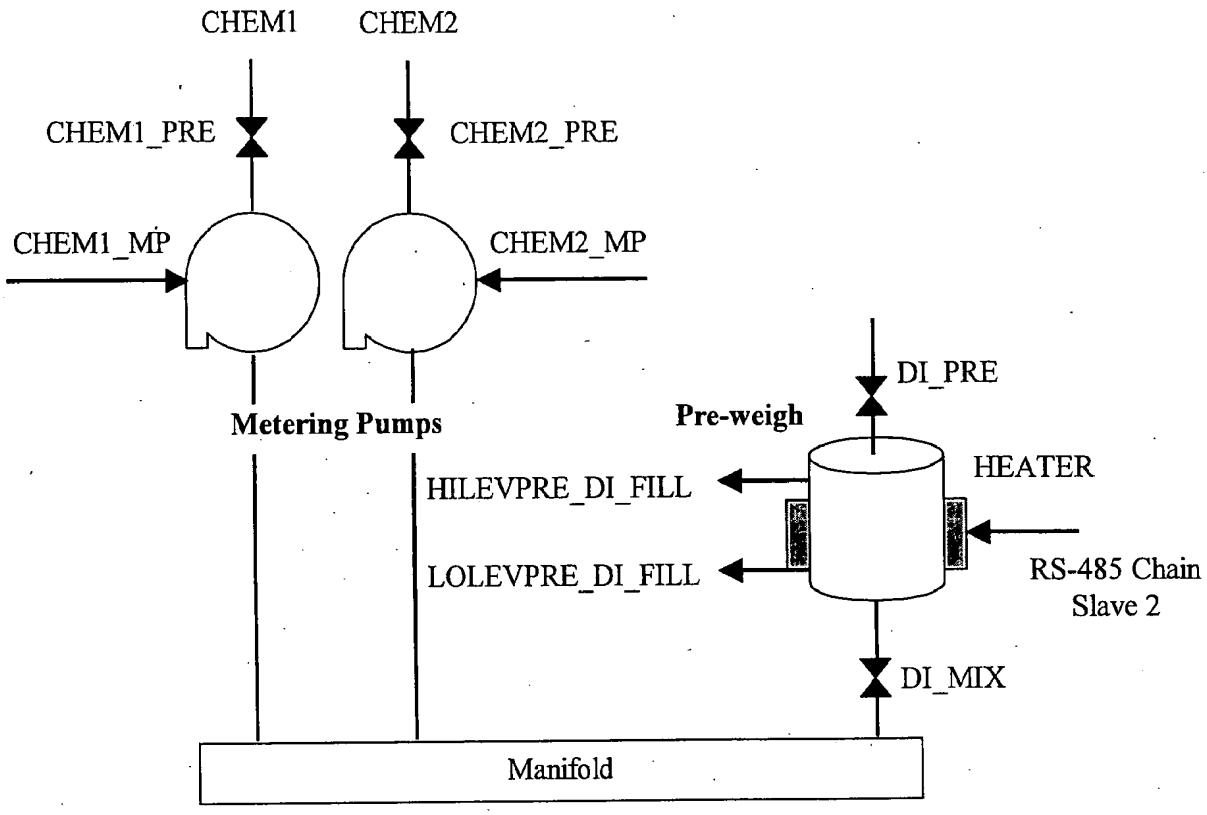


Figure 5 CHEM supply detail (Base configuration)

Two metering pumps are used to measure the quantity of chemicals CHEM1 and CHEM2. The pumps are driven by dry reed contact closures and are characterized by

- CC per stroke (contact closure cycle)
- Strokes per minute

The number of strokes are calculated based on the desired quantity of chemical. The pumps are activated for that number of strokes at the desired speed.

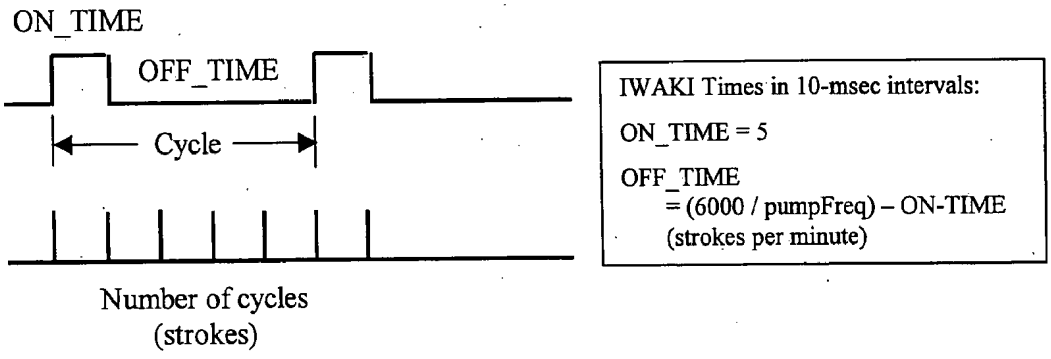


Figure 6 Metering pump activation

The vessel for DI_FILL uses the Pre-weigh algorithm to keep the tank filled with De-ionized Water (DI). A heater keeps the temperature of DI at a level consistent with

recipe requirements. The DI_FILL valve is opened to transfer the DI from the Pre-weigh to the Main Tank. The time of valve opening is a function of:

- Total amount of DI.
- Valve characteristics (CC per minute at atmospheric pressure).

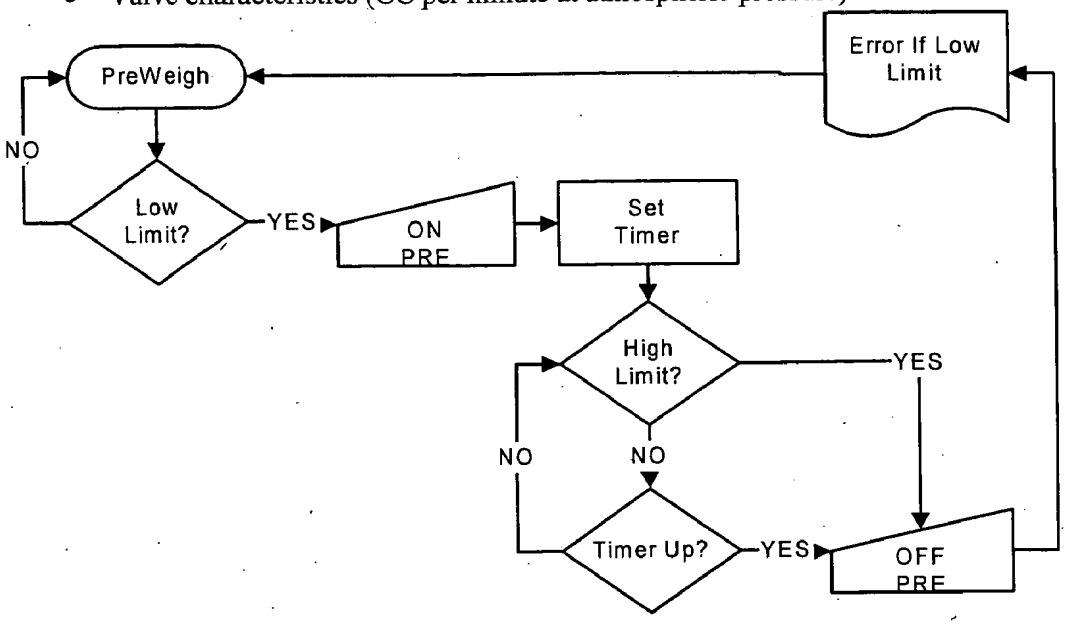


Figure 7 Simplified Pre-Weigh algorithm

Pre-weigh option

Option B uses two (2) tanks to accumulate chemical so that it will be ready to dispense when needed. The Pre-weigh option replaces the Metering Pumps in Figure 5.

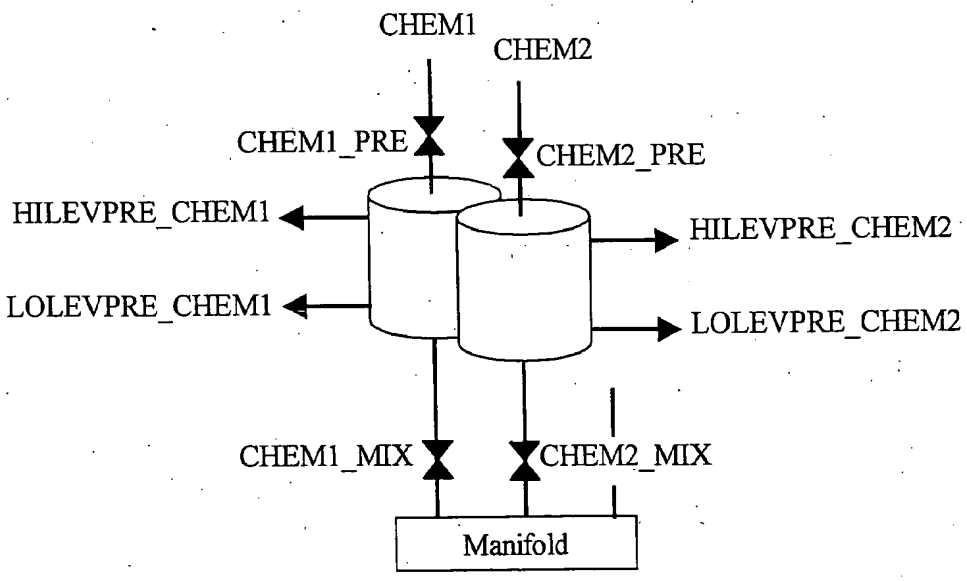


Figure 8 Pre-weigh option (option B)

In each case:

- The inlet valve is **opened** when the corresponding LO LEVEL SENSOR becomes TRUE (see Figure 8).
- The inlet valve is **closed** when the corresponding HI LEVEL SENSOR becomes TRUE.
- The outlet valve is opened for a certain time period when needed to dispense the chemical. This time period is calculated to dispense the appropriate amount. Liquid is fed to the main tank by gravity.
- The LO LEVEL SENSOR is set such as to have the minimum amount of needed liquid in the tank.

Metered Chemical Delivery option

This option provides one (option D1) or two (option D2) channels of metered chemical delivery to the chamber.

Liquid Flow Controller

FCO1	Analog Output channel Controls fluid during re-circulation (CDV is normally open). Controls fluid during chem. delivery (CDV is commanded closed).
FMO1	Analog Input channel provides flow read back.
FCO2	Analog Output channel (used for option D2).
FMO2	Analog Input channel provides flow read back.

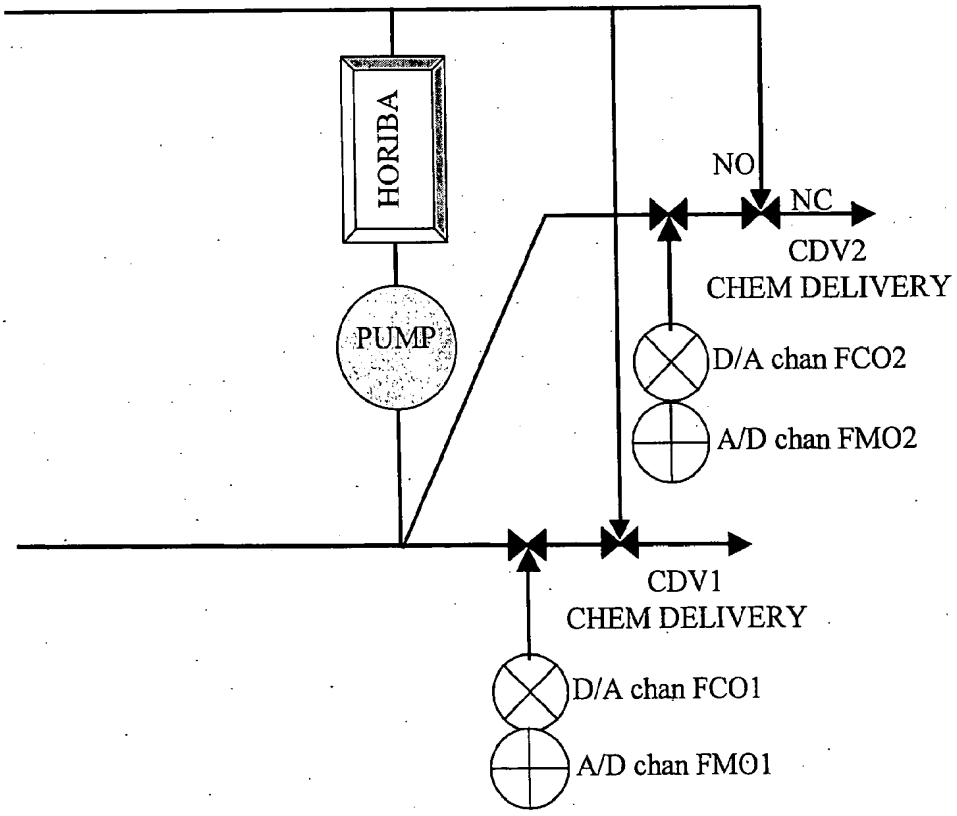


Figure 9 Metered Chemical Delivery option (option D)

Digital Outputs on the PK2600

Digital Outputs are implemented by the ULN2803 sinking driver and are located in **Digital Group 2**.

Logical Name	Usage	Physical Name	Pin Number
CDV1	3-way Chem. Delivery Valve. OFF: flow recirculates. ON: chemical is delivered to chamber.	HVB00	Pin 1
CDV2	3-way Chem. Delivery Valve. OFF: flow recirculates. ON: chemical is delivered to chamber.	HVB01	Pin 2
RECLAIM_ DRAIN1	3-way valve to reclaim chemical from chamber 1 OFF: chemical flows back into tank ON: chemical is dumped in the drain	HVB02	Pin 3
RECLAIM_ DRAIN2	3-way valve to reclaim chemical from chamber 2 OFF: chemical flows back into tank ON: chemical is dumped in the drain	HVB03	Pin 4
PROCESS_ PUMP	This is a positive-displacement pump and is stroked ON/OFF	HVB04	Pin 14
DRAIN	Sends contents of tank to drain during Pour-up.	HVB05	Pin 15
DI_FLUSH	De-ionized water is used to add H_2O during Flush	HVB06	Pin 16
N2	Nitrogen is used during Purge	HVB07	Pin 17
MAINT_ DRAIN	Valve used by maintenance personnel to completely drain the tank.	HVB08	Pin 5
DI_PRE	Supplies DI to FILL the Pre-Weigh tank	HVB09	Pin 6
DI_MIX	De-ionized water is added to mixing manifold from Pre-Weigh Tank	HVB10	Pin 7
CHEM1_PRE	When this solenoid is turned on, chemical 1 is supplied to either the metering pump or the pre-weigh tank	HVB11	Pin 8
CHEM1_MP	Drives relay to provide dry reed contact to CHEM1 Metering Pump	HVB12	Pin 18
CHEM2_PRE	When this solenoid is turned on, chemical 2 is supplied to either the metering pump or the pre-weigh tank	HVB13	Pin 19
CHEM2_MIX CHEM2_MP	(Option B) When this solenoid is turned on, chemical 2 is mixed from pre-weigh tank with the chemical from the main tank in the return manifold Drives relay to provide dry reed contact to CHEM1 Metering Pump	HVB14	Pin 20
Spare		HVB15	Pin 21
K	Free-wheeling diode connects to +24v supply		Pins 9, 10 Pins 22, 23

Table 2 Digital Outputs on the PK2600

Digital Outputs on the XP8100

This board has four headers, eight outputs in each of two headers and eight inputs in each of two headers (for a total of 16 additional Inputs and 16 additional Outputs).

Logical Name	Usage	Physical Name	Pin Number
CHEM1_REQ	Request to Facilities for Chem 1 availability	XPA00	Bank A pin 0[4]
CHEM1_ON	Facilities Open the Chem1 delivery valve	XPA01	Bank A pin 1
CHEM2_REQ	Request to Facilities for Chem 2 availability	XPA02	Bank A pin 2
CHEM2_ON	Facilities Open the Chem2 delivery valve	XPA03	Bank A pin 3
TANK_OK	Output is TRUE if the concentration of both chemicals in the tank is within the WARN limit, and the tank temperature is OK. Output is FALSE if the tank is in maintenance (This output may not be used if SECSI/SECSII is used)	XPA04	Bank A pin 4
ANALYT_PUMP	This is a metering pump used to supply chemical to the Analyzer (dry reed contact) (not used for DHF chemistry)	XPA05	Bank A pin 5
DI_RINSE1	When this output is turned on, the DI rinse valve for chamber 1 is opened (CDV1 & N2_Dry1 must be closed)	XPA06	Bank A pin 6
DI_RINSE2	When this output is turned on, the DI rinse valve for chamber 2 is opened (CDV2 & N2_Dry2 must be closed)	XPA07	Bank A pin 7
GND	Ground		Follows Bank A pin 7
K	Free-wheeling diode connects to +24v supply		Follows Bank A GND
N2_DRY1	When this output is turned on, the N2 dry valve for chamber 1 is opened (CDV1 & DI_Rinse1 must be closed)	XPA08	Bank A pin 8
N2_DRY2	When this output is turned on, the N2 dry valve for chamber 2 is opened (CDV2 & DI_Rinse2 must be closed)	XPA09	Bank A pin 9
CHEM1_MIX	(Option B) When this solenoid is turned on, chemical 1 is mixed from pre-weigh tank with the chemical from the main tank in the return manifold	XPA10	Bank A pin 10
CHEM2_MIX	(Option B) When this solenoid is turned on, chemical 2 is mixed from pre-weigh tank with the chemical from the main tank in the return manifold	XPA11	Bank A pin 11
Spare		XPA12	Bank A pin 12
Spare		XPA13	Bank A pin 13
Spare		XPA14	Bank A pin 14
Spare		XPA15	Bank A pin 15
GND	Ground		Follows Bank A pin 15

[4] Assuming the use of Field Wiring Terminals (FWT's)

Logical Name	Usage	Physical Name	Pin Number
K	Free-wheeling diode connects to +24v supply		Follows Bank A GND

Table 3 Digital Outputs on the XP8100

Digital Inputs on the PK2600

The PK2600 has a bank of 16 digital inputs, located in **Digital Group 1**.

Logical Name	Usage	Physical Name	Pin Number
TOOL_RDY	This is a HIGH-true input (+5vdc at the PK2600), signifying that the Tool is Ready to process wafers (+5v means Tool is Ready).	HVA00	Pin 1
MAX_LEVEL	This is a LOW-true input signifying that the level in the Tank is too high. CLOOP (Closed-loop control) is inhibited as long as this input is LOW.	HVA01	Pin 2
HI_LEVEL	This is a LOW-true input used.to stop filling the tank during a Pour-up operation	HVA02	Pin 3
LO_LEVEL	This is a LOW-true input used to stop emptying the tank during a Pour-up operation	HVA03	Pin 4
REP_LEVEL	This is a LOW-true input used to signal the Replenish cycle.	HVA04	Pin 14
MAINHTR_ OVERTEMP	This input goes LOW if the main heater is in an over temperature condition (System Error)	HVA05	Pin 15
HILEVPRE_DI_FILL	Senses that the level in the DI_FILL Pre-weigh tank is HIGH (stop adding chemical). Option B.	HVA06	Pin 16
LOLEVPRE_ DI_FILL	Senses that the level in the CHEM2 Pre-weigh tank is LOW (commence adding chemical). Option B.	HVA07	Pin 17
DIHTR_ OVERTEMP	This input goes LOW if the DI heater (see Figure 5) is in an over temperature condition (System Error)	HVA08	Pin 5
HILEVPRE_CHEM1	Senses that the level in the CHEM1 Pre-weigh tank is HIGH (stop adding chemical). Option B.	HVA09	Pin 6
LOLEVPRE_CHEM1	Senses that the level in the CHEM1 Pre-weigh tank is LOW (commence adding chemical). Option B.	HVA10	Pin 7
HILEVPRE_CHEM2	Senses that the level in the CHEM2 Pre-weigh tank is HIGH (stop adding chemical). Option B.	HVA11	Pin 8
LOLEVPRE_CHEM2	Senses that the level in the CHEM2 Pre-weigh tank is LOW (commence adding chemical). Option B.	HVA12	Pin 18
AUTO_RESTART	If this input is LOW, the controller automatically restarts the SCAN cycle on power-up without waiting for the operator to push a button.	HVA13	Pin 19
LEAK_DET	This input goes LOW if a leak occurs	HVA14	Pin 20
THERMOSTAT	The thermostat connected to this input goes LOW for an over-temperature condition.	HVA15	Pin 21
GND	Ground		Pins 11, 12, 13, 24, 25

Table 4 Digital Inputs on the PK2600

Digital Inputs on the XP8100

This board has four headers, eight outputs in each of two headers and eight inputs in each of two headers (for a total of 16 additional Inputs and 16 additional Outputs).

Logical Name	Usage	Physical Name	Pin Number
CHEM1_INQUE	Chem 1 currently unavailable	XPB00	Bank B pin 0[5]
CHEM1_IS_ON	Facilities Chem1 delivery valve open	XPB01	Bank B pin 1
CHEM2_INQUE	Chem 2 currently unavailable	XPB02	Bank B pin 2
CHEM2_IS_ON	Facilities Chem2 delivery valve open	XPB03	Bank B pin 3
PROCESS_START1	Tool is requesting chamber 1 start process	XPB04	Bank B pin 4
PROCESS_START2	Tool is requesting chamber 2 start process	XPB05	Bank B pin 5
spare		XPB06	Bank B pin 6
spare		XPB07	Bank B pin 7
GND	Ground		Follows Bank B pin 7
ENA_CLOOP	Ground this input to enable CLOOP action Must also enable software CLOOP = 1	XPB08	Bank B pin 8
spare		XPB09	Bank B pin 9
spare		XPB10	Bank B pin 10
spare		XPB11	Bank B pin 11
spare		XPB12	Bank B pin 12
spare		XPB13	Bank B pin 13
spare		XPB14	Bank B pin 14
spare		XPB15	Bank B pin 15
GND	Ground		Follows Bank B pin 15

Table 5 Digital Inputs on the XP8100

[5] Assuming the use of Field Wiring Terminals (FWT's)

Operational Modes

MENU

Allows the operator to select the other modes
Entered upon startup, unless AUTO_RESTART is TRUE. Returns to MENU if the operator pushed the MENU (or MEN) button
Menu Selections:

SCAN	
PARAMETERS	Password protected
MAINTENANCE	Password protected
POUR-UP	Password protected
SET HORIBA	

SCAN

This is the main operational mode, where Analytical Measurements and Digital Inputs are sampled, and Digital Outputs are activated. The PROCESS PUMP is running continuously in this mode, as well as the ANALYTICAL PUMP for chemistries other than DHF . The mode is entered in one of two ways:

- Operator pushes the SCAN MODE key when the program is in the MENU state
- Automatically if Digital Input AUTO_RESTART is grounded.

The SCAN MODE can be stopped by operator request by pushing the MEN key. If this key is pushed, the software completes the current sequence, and reenters the MENU state.

The scan mode consists of two phases:

- Obtain and average NUM_MEAS measurements.
- Perform Closed-Loop control action if CLOOP has been set = 1.

POUR-UP

The Pour-Up mode can be initiated in one of two ways:

- On command from the LDM Master. This is based on time of operation, and state of the other tanks.
- By the operator from the MENU mode or MAINTENANCE mode (requires password).

Refer to Figure 4 for the placement of valves and flow elements.

The Pour-Up sequence is shown in Figure 10.

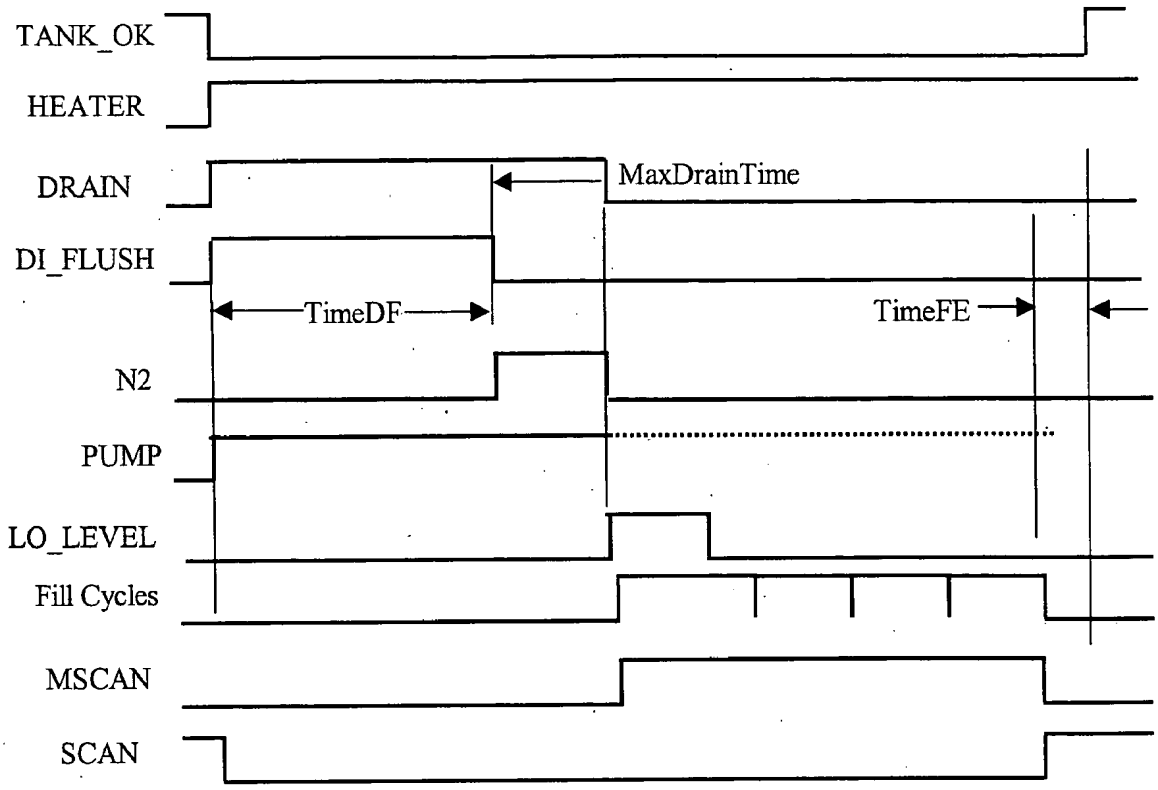


Figure 10 Pour-Up Mode

All steps testing LO_LEVEL and HI_LEVEL employ timeouts. That means that a SYSTEM ERROR condition occurs if the desired level is not achieved within a specified time period (this is a compile-time constant).

1. Set FALSE digital output TANK_OK to flag "Tank is not OK". This state remains during the entire Pour-Up sequence.
2. The heater in ON for the entire sequence..
3. A ***Flush and Drain Part A*** cycle consists of the following:
   - Open DRAIN valve.
   - Open the DI_FLUSH valve.
   - Run the Process PUMP.
   - This simultaneously drains the tank and flushes the entire system, including the Horiba and the Manifold.
   - This state remains for TimeDF (one of the PARAMETERs).
4. A ***Flush and Drain Part B*** cycle consists of the following:
   - The DI_FLUSH valve is turned off.
   - The N2 valve is turned on to force the tank and associated plumbing to drain.
   - Drain tank until digital input LO_LEVEL becomes TRUE (SYSTEM ERROR if MaxDrainTime[6] is exceeded).
   - Close DRAIN and N2 valves.
   - This completes the Flush and Drain cycle, followed by Fill cycles.

[6] MaxDrainTime ia a compile-time parameter (not part of PARAMETERS mode).

5. Several ***Fill*** cycles (four in this design) are used to fill the tank. The intent of separating the fill cycles is to achieve a full tank with the desired chemical concentration as soon as possible. Each cycle fills a (programmable) fraction (FRAC) of the tank. In this design, this is FRAC1 = 0.5, FRAC2 = 0.25, FRAC3 = 0.125, FRAC4 = 0.125. The total must equal to 1.0.

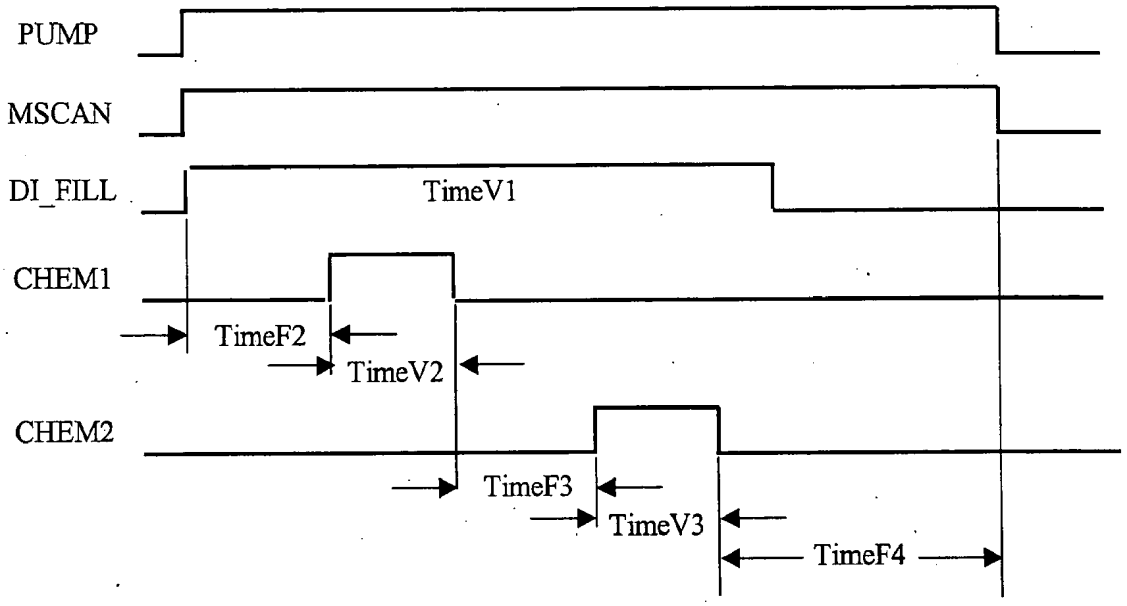


Figure 11 Fill Cycle Details (SPM chemistry)

A ***Fill*** cycle consists of the following (see Figure 11):

- This picture applies to chemistries like SPM, where the two chemicals must be added separate from each other.
- TimeF2, TimeF3, and TimeF4 are fixed for all instances of the Fill cycle (compile-time parameters).
- TimeV1, TimeV2 and TimeV3 are determined by the operator to satisfy the FRAC of the 1st Fill cycle. The program calculates the times for the other instances based upon the FRAC for that instance, and the chemical composition at the end of the Fill cycle. TimeV1 is determined by FRAC only, whereas TimeV2 and TimeV3 are determined by FRAC, and modified by the composition.
- Open DI_FILL for time TimeV1. It is desirable that de-ionized water flows while chemicals are being added.
- Open CHEM1 for time TimeV2 after a delay of TimeF2.
- Open CHEM2 for time TimeV3 after a delay of TimeF3.
- The Modified Scan sequence (MSCAN) is used to measure the composition during the Fill cycle.
- The composition at the end of TimeF4 is used to calculate the variable times for the next instance of the fill cycle.

6. The Modified SCAN sequence (MSCAN) consists of the following elements:
   - The PUMP is running to force liquid through the Horiba
   - Measurements are obtained as during normal SCAN.
   - CLOOP action is NOT performed.

- Measurements are not sent to Factory Automation[7].

7. The heater is on during the entire Fill cycle.
8. The normal SCAN sequence is run for TimeFE after the last Fill cycle. CLOOP action is performed if necessary to achieve correct concentration.
9. Turn on TANK_OK digital output at the end of TimeFE, provided that concentration of both chemicals is in acceptable limits.

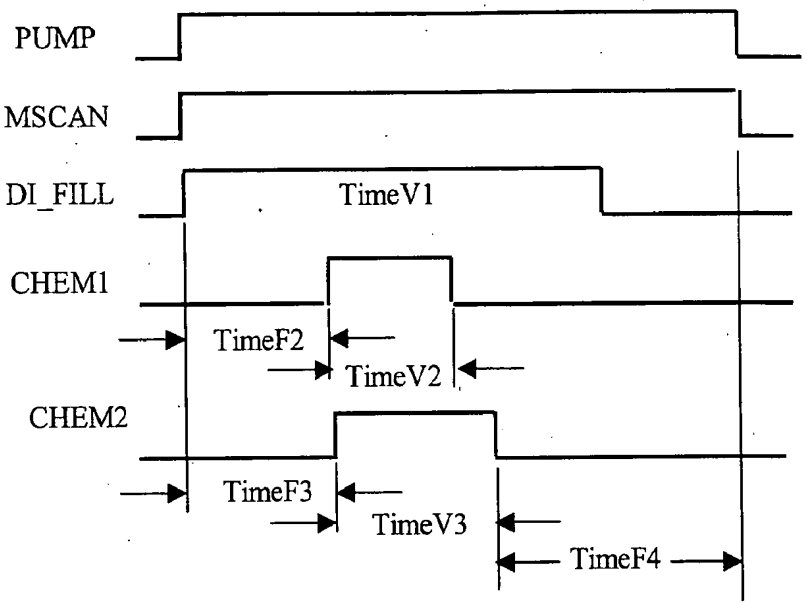


Figure 12 Fill Cycle Details (SC1 or SC2 chemistry)

- This picture applies to chemistries like SC1 or SC2, where the two chemicals can be added together (resulting in significant savings of time).
- TimeF2, TimeF3, and TimeF4 are fixed for all instances of the Fill cycle (compile-time parameters). Both TimeF2 and TimeF3 can be zero (0).

REPLENISH CYCLE

The Replenish Cycle is identical to the last Fill Cycle (FRAC 4) and is designed to replenish chemical used up during wafer processing. This cycle is triggered during SCAN by the REP_LEVEL digital input becoming TRUE.

The Replenish Cycle is performed asynchronous to SCAN. That is to say, TANK_OK is kept ON, and demands to supply chemical to the chamber are honored.

Display during Pour-Up

The display during Pour-Up has the heading "POUR UP", and a message identifying the step. Trend display is omitted. Measurements are displayed during the MSCAN and SCAN cycles. The following step messages are displayed:

FLUSH AND DRAIN, PART A
FLUSH AND DRAIN, PART B
1st FILL (<FRAC1> OF TANK)
2nd FILL (<FRAC2> OF TANK)
3rd FILL (<FRAC3> OF TANK)

[7] We can send them if they want them.

4th FILL (<FRAC4> OF TANK)
LAST POUR-UP STEP
REPLENISH

Target vs HH, H, L, LL

The classical Horiba Parameters are the limits HH, H, L, and LL. This design replaces these limits with the following:

TARGET	The target concentration in % of weight.
WARN	The deviation in either direction (in % of target) for a WARN condition to exist.
ALARM	The deviation in either direction (in % of target)for an ALARM condition to exist.

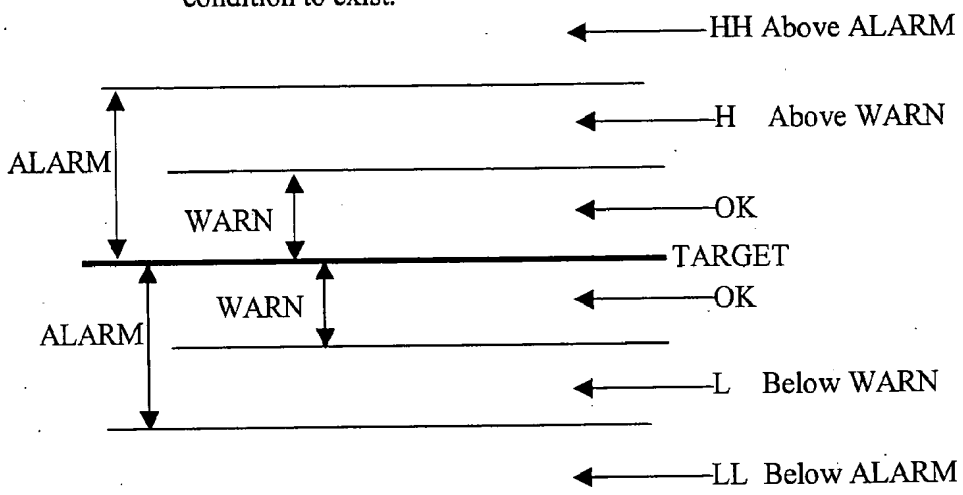


Figure 13 WARN and ALARM levels relative to TARGET

PARAMETER

The Parameter mode is entered by the operator from the MENU mode (requires password). Parameters are stored in EEPROM on board of the OP7100 and restored upon power-up. They can also be overridden by commands from the LDM Master (EEPROM is refreshed at that time). The following is the list of parameters defined at this time. Notations of the form <chem1> are placeholders and are replaced by actual chemical names. The notation RV means that the parameter is overridden by remote command from the LDM master. Parameter prompts are supplied only if the option has been implemented.

Prompt/software name	Notes	RV?
"PROCESS PUMP STROKES/MIN" procPumpTimeOnOff		
"ANALYT PUMP MAX STROKES/MIN" lytPumpMinTimeOff		
"ANALYT PUMP ML/STROKE" lytPumpMliters		
"ANALYT PUMP ML/MIN" lytPumpFlow		

Prompt/software name	Notes	RV?
"<chem1> PUMP STROKES/MIN" chem1PumpTimeOff	Base Configuration only	
"<chem1> PUMP ML/STROKE" chem1PumpMliters	Base Configuration only	
"<chem2> PUMP STROKES/MIN" chem2PumpTimeOff	Base Configuration only	
"<chem2> PUMP ML/STROKE" chem2PumpMliters	Base Configuration only	
"PROCESS TEMPERATURE TARGET" procTemperTarg		RV
"PROCESS TEMPERATURE ALARM (%)" procTemperLarm	% of target	
"PROCESS TEMPERATURE WARN (%)" procTemperWarn	% of target	
"DI HEATER TEMPERATURE TARGET" diTemperTarg		RV
"DI HEATER TEMPERATURE ALARM (%)" diTemperLarm	% of target	
"DI HEATER TEMPERATURE WARN (%)" diTemperWarn	% of target	
"MAX CONCENTRATION <chem1>" chem1MaxConc	Used to scale trend record	
"MAX CONCENTRATION <chem2>" chem2MaxConc	Used to scale trend record	
"CLOOP GAIN <chem1>" chem1CloopGain	If CLOOP is defined	
"CLOOP GAIN <chem2>" chem2CloopGain	If CLOOP is defined	
"CLOOP DEAD BAND <chem1>" chem1CloopDead	If CLOOP is defined	
"CLOOP DEAD BAND <chem2>" chem2CloopDead	If CLOOP is defined	
"<chem1> TARGET (%WT)" chem1Targ		RV

Prompt/software name	Notes	RV?
"<chem1> ALARM LEVEL (% OF TARGET)" chem1Larm		
"<chem1> WARN LEVEL(% OF TARGET)"[8] chem1Warn		
"<chem2> TARGET (%WT)" chem2Targ		RV
"<chem2> ALARM LEVEL (% OF TARGET)" chem2Larm		
"<chem2> WARN LEVEL (% OF TARGET)"[9] chem2Warn		
"CHEM DELIVERY TIME 1 (SEC)" cdv1Time	CHAMBERS >= 1	RV
"CHEM DELIVERY TIME 2 (SEC)" cdv2Time	CHAMBERS >= 2	RV
"CHEM DELIVERY TIME 3 (SEC)" cdv3Time	CHAMBERS >= 3	RV
"CHEM DELIVERY TIME 4 (SEC)" cdv4Time	CHAMBERS >= 4	RV
"CHEM DELIVERY 1 (ML)" cdv1Mliters	Option D1 and D2 CHAMBERS >= 1	RV
"CHEM DELIVERY 2 (ML)" cdv2Mliters	Option D2 CHAMBERS >= 2	RV
"CHEM DELIVERY 3 (ML)" cdv3Mliters	Option D1 and D2 CHAMBERS >= 3	RV
"CHEM DELIVERY 4 (ML)" cdv4Mliters	Option D2 CHAMBERS >= 4	RV
"CHEM DELIVERY FLOW ALARM (%)" cdvLarm	Option D1 and D2	
"CHEM DELIVERY FLOW WARN (%)" cdvWarn	Option D1 and D2	
"RECLAIM DRAIN 1 (SEC)" recDrain1Time	Time to Drain CHAMBERS >= 1	RV
"RECLAIM DRAIN 2 (SEC)" recDrain2Time	Time to Drain CHAMBERS >= 2	RV

[8] The program checks if the limits are non-zero, and that ALARM > WARN.

[9] The program checks if the limits are non-zero, and that ALARM > WARN.

Prompt/software name	Notes	RV?
"RECLAIM DRAIN 3 (SEC)" recDrain3Time	Time to Drain CHAMBERS >= 3	RV
"RECLAIM DRAIN 4 (SEC)" recDrain4Time	Time to Drain CHAMBERS >= 4	RV
"DI RINSE 1 (SEC)" diRinse1Time	Time for DI rinse CHAMBERS >= 1	RV
"DI RINSE 2 (SEC)" diRinse2Time	Time for DI rinse CHAMBERS >= 2	RV
"DI RINSE 3 (SEC)" diRinse3Time	Time for DI rinse CHAMBERS >= 3	RV
"DI RINSE 4 (SEC)" diRinse4Time	Time for DI rinse CHAMBERS >= 4	RV
"N2 DRY 1 (SEC)" n2Dry1Time	Time for N2 Dry CHAMBERS >= 1	RV
"N2 DRY 2 (SEC)" n2Dry2Time	Time for N2 Dry CHAMBERS >= 2	RV
"N2 DRY 3 (SEC)" n2Dry3Time	Time for N2 Dry CHAMBERS >= 3	RV
"N2 DRY 4 (SEC)" n2Dry4Time	Time for N2 Dry CHAMBERS >= 4	RV
"FRACTION FOR 1ST POUR UP SEQ" pourUp1Frac		
"FRACTION FOR 2ND POUR UP SEQ" pourUp2Frac		
"FRACTION FOR 3RD POUR UP SEQ" pourUp3Frac		
"FRACTION FOR 4TH POUR UP SEQ" pourUp4Frac		
"DI TIME FOR POUR-UP" diPourUpTime		
"<chem1> POUR UP TIME" chem1PourUpTime		
"<chem2> POUR UP TIME" chem2PourUpTime		
"DELAY BETWEEN DRAIN AND FLUSH" timeDF		

Prompt/software name	Notes	RV?
"DELAY FOR LAST PART OF POUR-UP" timeFE		
"DELAY BEFORE ADDING <chem1>" timeF2		
"DELAY BEFORE ADDING <chem2>" timeF3		
"DELAY TO ACHIEVE MIXTURE" timeF4		
"TIME OF DAY (HOUR)" rtcHh		
"TIME OF DAY (MINUTE)" rtcMm		
" NEGATIVE FLAG" negFlag		
" HORIBA FORMAT" ribaForm		

Table 6 Parameters, which can be changed by operator

MAINTENANCE

The Maintenance mode is entered by the operator from the MENU mode (requires password).

Note: Some parameters can be changed while in the Maintenance Mode. These parameters are restored to the values stored in EEPROM when the Maintenance Mode is exited.

"READ TANK"	Continuously run the pump and display measurements until stopped. Control action and averaging not used here.
"DIGITAL INPUTS"	Displays state of all digital inputs
"DIGITAL OUTPUTS"	Allows the operator to activate any of the digital outputs.
"ANALOG INPUTS"	Displays the values of the Analog Inputs.
"ANALOG OUTPUTS"	Allows the operator to change the value of the analog outputs.
"PROCESS PUMP"	Allows independent operation of the Process Pump for testing purposes"
"CHEMtoTOOL CTRL"	Allows the operator to run Chem. Delivery for a specified value and time.

Base configuration (Figure 4)

- Pick a CDV: OPEN for xx seconds INCREASE/DECREASE Process Pump output (display current strokes/min)
- Pick another CDV (if allowed by configuration)? if yes, all of the above applies to additional CDV flow stream

Flow Control option (Figure 9)

- pick an LFC (Liquid Flow Controller): View/change set point (show readback on same screen)
  OPEN associated CDV for xx seconds. INCREASE/DECREASE Process Pump output (display current strokes/min)
- Pick another LFC (if allowed by configuration)? if yes, all of the above applies to additional LFC flow stream

"CHEM INPUT CTRL" Allows the operator to control chemical supply to the manifold

Base configuration (Figure 5)

Pick a chemical:

- enable/disable CHEM_PRE valve (tech may use water to test)
- view/change volumeToPump [10](i.e. 300 ml)

Pre-weigh option (Figure 8)

Pick a chemical:

- enable/disable CHEM_PRE valve (tech may use water to test).
- OPEN associated CHEM_MIX valve for xx seconds.

"DISPLAY LIMITS" Displays the Process Limits being used at this time (they may have been downloaded by the LDM Master).

"FLUSH & DRAIN" This performs the Flush and Drain sequence of Figure 10.

"FILL SEQUENCE" This allows the testing of the accuracy of the fill fractions (FRAC 1, FRAC 2, FRAC 3, or FRAC 4) of Figure 11.

Analytical Data is displayed on the same screen.

"TEMP CONTROL" This performs set point control to the temperature controllers:

- view/change setpoint (show readback on same screen)
- view/set alarm limits (show alarms on same screen)
- the display includes RS485 messages: transmit/receive/error

"SET HORIBA" This allows the operator to set the Horiba in parallel mode.

"SECS MESSAGES" This function allows the operator to test send/receive of SECSII messages.

- Send Message: hello (s2f13) (show response on same screen)
- data : provide list of data options (i.e. MainTemp, DITemp, FC1Flow)
- View Received Message: display the message stream

[10] VolumeToPump is translated to seconds (timeToPump)from PUMP STROKES/MIN and PUMP ML/STROKE.

Control Action

Control Action is implemented by opening the CHEM1 or CHEM2 valve for a period of time. The calculated spikeTime is in units of 10 msecs (e.g. if spikeTime is calculated at 200, then the valve is kept open for 2.00 seconds). Minimum spikeTime is 100 (1 second), and maximum spikeTime is 9999 (99.99 seconds).

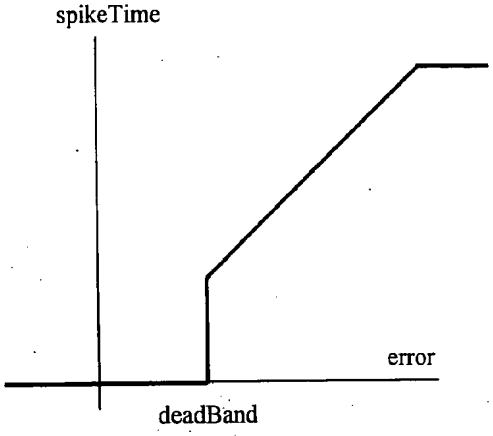
The setpoint R is the same as the Horiba Target.

$R = TARGET$

The error E is given by the difference between the setpoint R and the measurement B

$E = R - B$

No control action is taken if the error is below the deadBand



If the error is above the deadBand, control action is given by

spikeTime = gain * error

Gain and deadBand are parameters, which can be changed in the Parameter mode, adjustable for each chemical.

For example, if the NH_4OH measurement is 4.9%, the L limit is 5.9%, the NH_4OH deadBand is 0.7, and the NH_4OH gain is 1.5, then:

error = 5.9 – 4.9 = 1.0 (this is greater than 0.7, so spikeTime is computed).

spikeTime = 1.5 * 1.0 = 1.50 sec

This is multiplied by 100 to give 150 10-msec units for the activation of the valve.

Chem. Delivery

Delivery of chemical to the chamber can only take place while SCAN is operational, and the tank is within limits (TANK_OK is TRUE). Delivery can take place at the following times:

- On command from the LDM Master
- In the maintenance mode.

1. Set 2-way valve CDV in the "Chem. Delivery" direction.
2. Set the input to the Flow Controller at the desired flow for the desired time.
3. This could be a good place for feed-forward control action. The quantities of CHEM1, CHEM2, and DI could be calculated to compensate for chemical being drawn off to the chamber.

Error Handling

The scan can be stopped for any of the following reasons. In each case, the reason for the failure is displayed, the operator must push MENU to display the Main Menu, and push SCAN to restart the scan. The following codes are assigned to the failures:

Code	*Message*	*Explanation*
1	"OPERATOR STOP"	This occurs when the operator pushes MENU while in scan. The screen displays the MENU. The error is reported to Factory Automation.
2	"LEAK DETECTED"	A LOW at HVA14 Digital Input.
3	"PROCESS OVERTEMPERATURE"	A LOW at HVA15 Digital Input.
4	"TOOL NOT READY"	A LOW at HVA00 Digital Input.
5	"HORIBA TIMEOUT"	Occurs when the Controller attempts to communicate with the Horiba, and the latter does not answer within HORIBA_TMO seconds. Probably due to disconnected cable.
6	"NO NEW DATA"	Occurs if the Horiba does answer, but the Data Number does not change within MAX_HORIBA_WAIT seconds. Probably due to operator not pushing ESC after putting Horiba into parallel mode.
7	"HORIBA ERROR"	"Bad" error reported by Horiba. See Table 8.
8	"DI HEATER OVERTEMP"	The DI heater (see Figure 5) is in an over temperature condition
9	"MAIN HEATER OVERTEMP"	The main heater is in an over temperature condition. Error 3 is reported if the thermostat in the main tank trips. Error 9 is reported if the Digital Input from the main heater trips.
10	"LO_LEVEL NOT REACHED"	The desired level in the Pour-Up mode (see Figure 10) is not achieved within a specified time period

Table 7 System Errors

Monitor Error	Bad errors:	1 = No monochromator 2 = No reference wavelength 3 = No R-S switching mirror
	Good errors:	none
Data Error	Bad errors:	1 = Total concentration is too low 2 = Exceeds max data (x.xxx or xxx.x) 3 = Abnormal wavelength 4 = Insufficient light 5 = Unstable light 6 = Failed to get new data[11] 7 = Exit Scan
	Good errors:	none
Warning Error	Bad errors:	2 = Abnormal liquid temperature
	Good errors:	1 = Warming up 3 = Above or below the Process Warn limit 4 = Above or below the Process Alarm limit

Table 8 Horiba errors

[11] These errors are synthesized by the Scan Program

Operational Screens

Menu Display

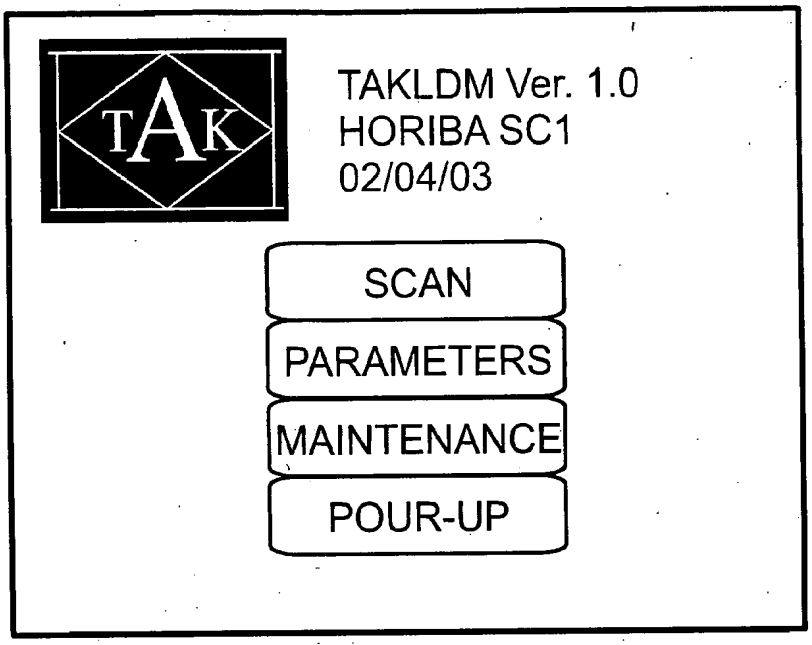


Figure 14 MENU Screen

See the section 'Operational Modes' on page 19

Waiting for Horiba

The "Waiting for Horiba" screen appears on the local display when the SCAN MODE has been entered and remains until the 1st measurement has been received from the Horiba.

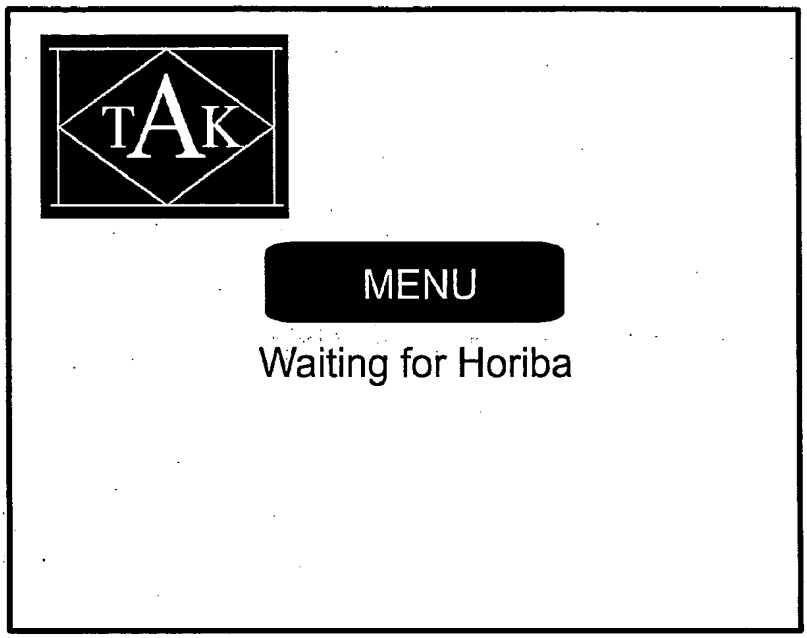


Figure 15 Waiting for Horiba

Measurement Display

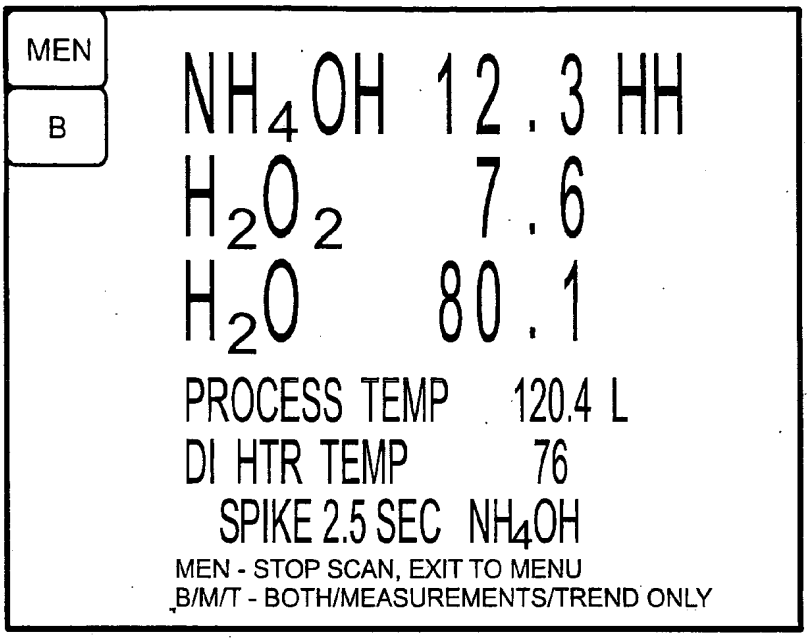


Figure 16 Measurement Display

This is the measurement display. The following measurements are displayed on this screen:

- The concentration of the three (3) measured chemicals is displayed in percent units.
- The PROCESS TEMPERATURE and DI HEATER TEMPERATURE are displayed in degrees C.

The display is followed by a modifier if one of the limits is violated (see Figure 13)

LL	measurement is below the ALARM limit
L	measurement is below the WARN limit, but above the ALARM limit
H	measurement is above the WARN limit, but below the ALARM limit
HH	measurement is above the ALARM limit.

MEN button

Pushing this button displays the "Menu" screen (see Figure 14).

B/M/T button

The original display mode is to display **both** the Measurement Screen and the Trend Screen alternatively at intervals of 6 seconds. The button displays 'B' in this display mode.

Pushing this button changes the display mode where only the Measurement Screen is displayed. The button displays 'M' in this display mode.

Pushing this button again changes the display mode where only the Trend Screen is displayed. The button displays 'T' in this display mode.

Pushing this button again changes the display mode back to 'B'.

SPIKE time message

This message appears only if control action has been calculated, and displays the time of the spike in seconds.

Trend Screen

The Trend Screen displays the trend record of two analysis values and the same buttons as the measurement screen along the left edge:

The scaling of the vertical axis (concentration) are two of the parameters, which can be changed in the Parameters Screen (MAX CONCENTRATION <chem1> and MAX CONCENTRATION <chem2>).

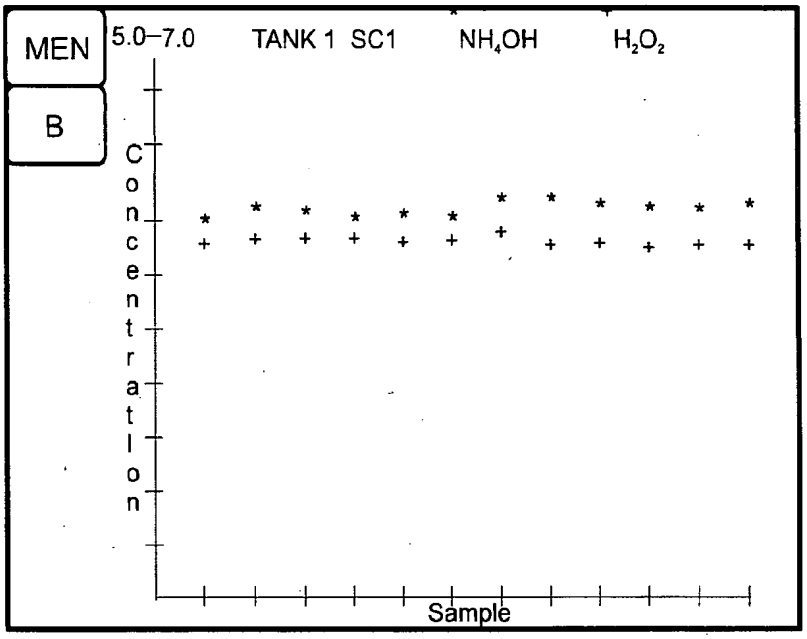


Figure 17 Trend Screen

System Error Screen

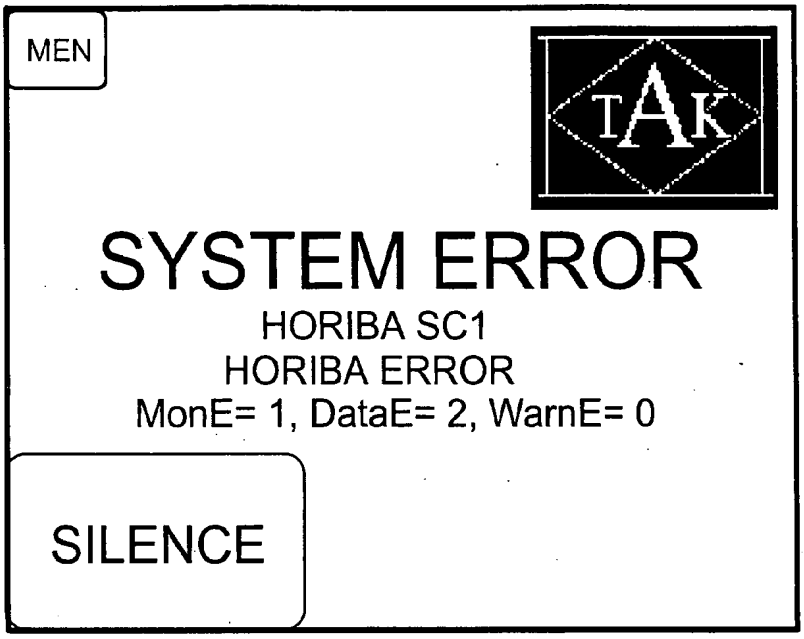


Figure 18 Typical System Error screen (shown locally and on remote)

This screen overrides the display mode established by the touch screen. The screen is displayed if a Horiba error or Detected error have been detected. Line 1 on the display has the message "SYSTEM ERROR", and line 2 the reason for the error. Figure 18 shows a System Error screen with a Horiba error. "MonE" stands for Monitor Error, "DataE" stands for Data Error, and "WarnE" stands for Warn Error. System Errors are shown in Table 7, and Horiba Errors are shown in Table 8

A SYSTEM ERROR screen invokes the sounding of the alarm at 1-second ON/OFF intervals. Push the SILENCE button to silence the alarm (the button changes to a black background).

Parameters Screen

Parameters are changed with the aid of the Virtual Keyboard. The Virtual Keyboard is removed (and normal display is restored) when all parameters have been examined and changed (if desired).

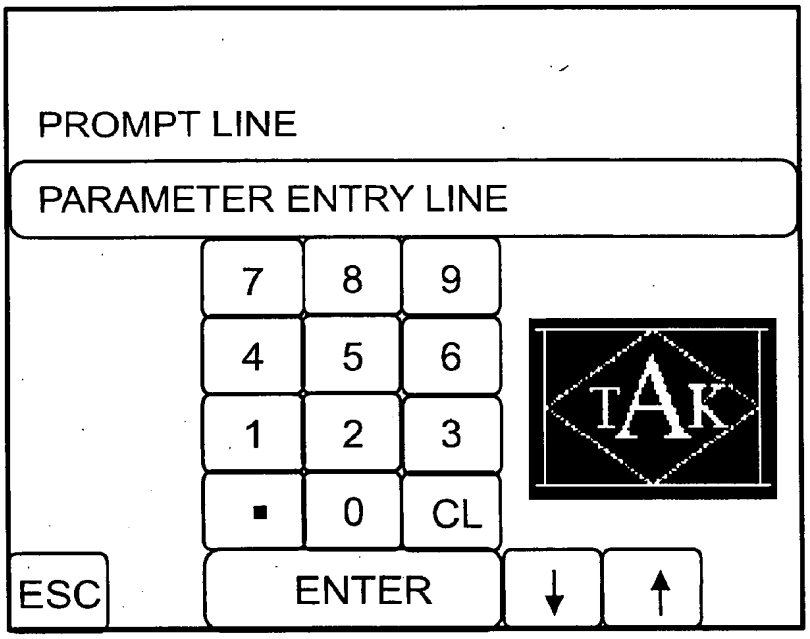


Figure 19 Virtual Keyboard

Numeric buttons

Pushing a numeric button the first time after a parameter has been displayed clears the parameter entry line and enters that key. Subsequent entry of numeric buttons (or the decimal point) enters successive characters.

CL button

Pushing the CL button clears the parameter entry line.

ENTER button

Pushing the ENTER button enters the displayed parameter in permanent and temporary storage and displays the next parameter. The list recycles to the beginning, if the end of the list is reached.

Down Arrow

Push the down arrow (↓) to view the next parameter without changing the current parameter. The list recycles to the beginning, if the end of the list is reached.

Up Arrow

Push the up arrow (↑) to view the prior parameter without changing the current parameter. . The list recycles to the end, if the beginning of the list is reached.

ESC button

Pushing the ESC button exits parameter entry and returns to the MENU screen. If any parameters were changed, they remain changed.

Prompt Line

A prompt line appears for each item, which is on the list of parameters, and meets selection criteria. An item does not appear, unless called for by the compile-time software configuration. For example, the CLOOP items do not appear, unless **`CLOOP=1`**. The prompt line consists of an explanatory message, the minimum value, and the maximum value.

Maintenance Screens

The operator can toggle between the two maintenance screens by pushing the 'NEXT' button. Push the 'MEN' button to get back to the menu.

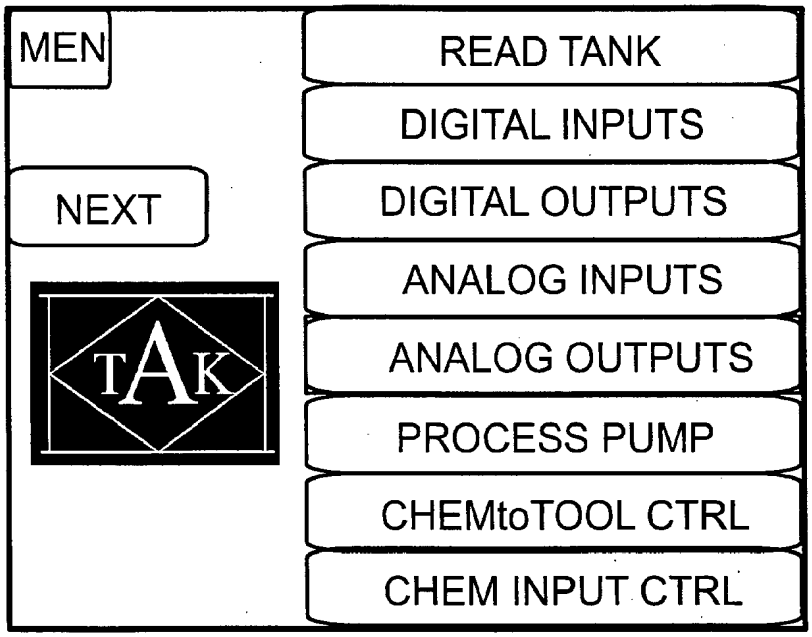


Figure 20 First Maintenance Screen

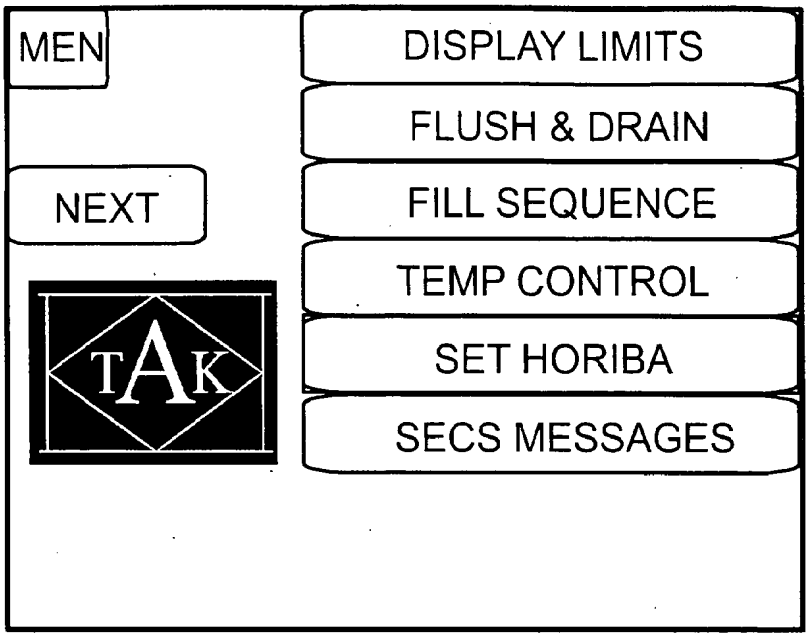


Figure 21 Second Maintenance Screen

Digital Output Screen

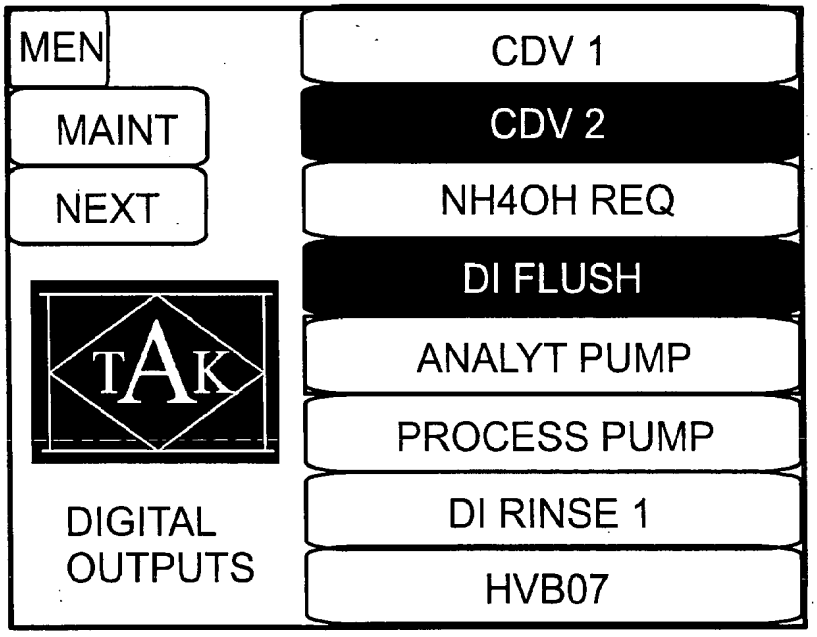


Figure 22 Typical Digital Output Screen

Each Digital Output screen has 8 buttons controlling and showing the state of digital outputs, and 3 buttons determining display action. There is a set of four (4) screens with 8 buttons each.

Push any of the digital output buttons to toggle the state of the output. The button shows black-on-white (normal video) if the output is TRUE, and white-on-black (reverse video) if the output is FALSE. For example, outputs CDV 2 and DI FLUSH are FALSE in Figure 22,

whereas the other outputs are TRUE. The buttons are shown in physical order (HVB00 to HVB15 on the PK2600, followed by XPA00 to XPA15 on the XP8100). The logical names in the USAGE tables determine the legend on the buttons. Substitution of actual chemical names (e.g. NH4OH in Figure 22) is controlled by information in the USAGE tables. Physical names (e.g. HVB07) are used if the output is not used in a logical function.

Push the NEXT button to show the next group of 8 outputs.

Push the MAINTENANCE button to get back to the maintenance screen.

Push the MEN button to get back to the MENU state.

Note: If the operator changes an output ON or OFF, the output stays in that state until the Maintenance mode is exited (at which point all outputs are turned off). In this manner, more than one output can be turned ON.

Digital Input Screen

The screens showing the states of Digital Inputs are similar, except that the figures in the shape of buttons are not buttons, but merely placeholders indicating the state of Digital Inputs. The shapes show black-on-white (normal video) if the input is TRUE, and white-on-black (reverse video) if the input is FALSE. There is a set of four (4) screens, showing all 32 of the buttons.

'Set Horiba' Screen

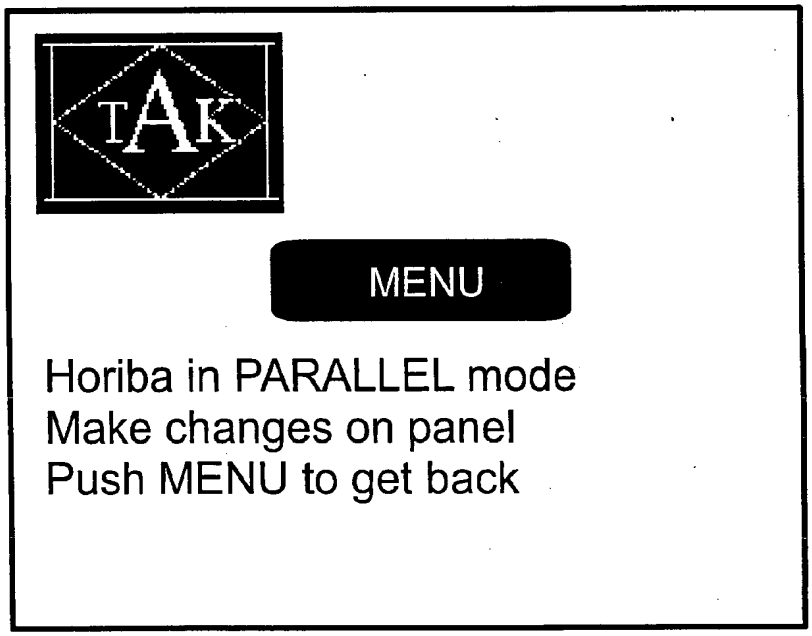


Figure 23 Horiba in Parallel mode

SET HORIBA

This mode allows the operator to have access to the Horiba front panel by setting the Horiba in parallel mode.

Note: limits are set in parameter mode, and not on the Horiba front panel (see the section 'Target vs HH, H, L, LL' on page 23)

Application Data Sheet

Application Information

Application Type::	Regular
Subject Matter::	Provisional
Suggested classification::	
Suggested Group Art Unit::	
CD-ROM or CD-R?::	None
Computer Readable Form (CRF)?::	No
Title::	CHEMICAL MIXING APPARATUS, SYSTEM AND METHOD
Attorney Docket Number::	9130-101
Request for Early Publication?::	No
Request for Non-Publication?::	No
Suggested Drawing Figure::	N/A
Total Drawing Sheets::	None
Small Entity?::	Yes
Petition included?::	No
Secrecy Order in Parent Appl.?::	No

Applicant Information	
Applicant Authority Type::	Inventor
Primary Citizenship Country::	U.S.A.
Status::	Full Capacity
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State or Province of Residence::	TX
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State or Province of mailing address:	TX
Postal or Zip Code of mailing address::	78621

Applicant Information	
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City of mailing address::	Austin
State or Province of mailing address:	TX
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Correspondence Information

Correspondence Customer Number::	36412
E-Mail address::	Kleinke@dsm-law.com

Representative Information

Representative Designation::	Registration Number::	Representative Name::
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Secondary	41,107	JEFFREY R. KAUFMAN

Domestic Priority Information

Application::	Continuity Type::	Parent Application::	Parent Filing Date::

Foreign Priority Information

Country::	Application number::	Filing Date::	Priority Claimed::

Assignee Information

Assignee name::